Trigeminal neuralgia

TO THE EDITOR: We are very interested in the article by Monteith et al.1 (Monteith SJ, Medel R, Kassell NF, et al: Transcranial magnetic resonance–guided focused ultrasound surgery for trigeminal neuralgia: a cadaveric and laboratory feasibility study. J Neurosurg 118:319–328, February 2013). Trigeminal neuralgia often induces severe pain and impairs quality of life, even with multimodal therapies. The trigeminal pain often results from offending artery compression to the trigeminal nerve. Monteith et al.1 performed a laboratory investigation in cadaveric specimens to clarify the feasibility of transcranial MR-guided focused ultrasound therapy for trigeminal neuralgia. They found that real-time MR thermometry demonstrated the heating effect of focused ultrasound on the trigeminal nerve with 10°C increments in temperature. Moreover, the heating effect may collateral spread to the internal acoustic canal (IAC).

Their study provided solid evidence that MR-guided focused ultrasound surgery (MRgFUS) is capable of increasing focal heating of up to 18°C in the trigeminal nerve of a cadaveric specimen at the root entry zone. Importantly, MRgFUS did not produce a significant heating effect on the skull base and surrounding neural structures in no-pass regions. However, there are some minor concerns. First, MRgFUS cannot avoid an off-target effect producing a local temperature effect on adjacent crucial neurovascular structures, such as the brainstem and cranial nerves, as the authors observed with the vestibular nerve in the region of the IAC. Their study leads readers to ask about the damaging heating effects on vascular structures, which can induce thrombus formation and lead to ischemic injury of the brainstem. Their study delivered results in cadaveric human specimens, but not in living animal models. Therefore, the pain reduction effect still cannot be estimated from their study. We fully agree that in vivo studies are warranted to ensure the safety and efficacy of MRgFUS in treating trigeminal neuralgia.

Zhi-Hong Zheng, MD
Yi Lin, MD
Pin-Shuo Su, MD
Peng-Wei Wang, MD
Wei-Ting Tsai, MD
Dueng-Yuan Hueng, MD, PhD
Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan

Reference

Response
We greatly appreciate the thoughtful comments from Dr. Zheng and colleagues. In our study, we investigated the potential use of transcranial MRgFUS treatment for trigeminal neuralgia. As Zheng et al. point out, there is concern regarding the collateral heating of adjacent structures, namely surrounding bone of the acoustic canal. Indeed, it was this concern that prompted specific design aspects of our investigation and the development of strategies to minimize these potential heating effects. From in vivo experimentation in swine and the results of thermal lesioning in the ventral intermediate nucleus of the thalamus in humans for the treatment of essential tremor,1 we have learned much in terms of local temperature effects. The lesion size is highly reproducible with an extremely sharp gradient between normal and necrotic tissue that is similar to that in other thermal lesioning modalities, such as radiofrequency, and is probably even more distinct than the gradient produced from ionizing radiation.4 This sharp lesion drop-off means that there is no damage to surrounding brain parenchyma. Experience in 30 patients treated for chronic pain and movement disorders, as described by Jeanmonod et al., confirms this sharp drop-off in a lesion created by FUS.2,3 No cases of thrombus formation or stroke in the region surrounding the lesion, as determined by diffusion-weighted imaging, were reported.

In trigeminal neuralgia, larger vessels near the trigeminal nerve would not be directly targeted, and this sharp energy drop-off would be utilized to target the nerve distant to the vascular structure. In addition, the heat-sink effect from rapid vascular flow helps defray heating of the vessel. It should also be noted that in the setting of trigeminal neuralgia, a higher “lesional” temperature—as currently utilized in FUS lesioning procedures for pain and movement disorders—would not be used since the goal is not to cause necrosis of the entire nerve, but to demyelinate and interrupt the pain fibers only.

Concern regarding the IAC is valid and was of particular interest in these experiments. The geometry of the re-
required positioning of the ultrasound transducer to target the trigeminal nerve is such that the ultrasound “shadow” falls onto the IAC. Bony absorption of ultrasound energy and subsequent heat generation were significantly mitigated by turning off transducer elements pointing at the IAC. Further optimization of this process will continue to address this issue and improve this collateral heating.

We agree with Zheng et al. as regards the determination of the pain-relieving effect. The cadaveric targeting model is clearly not helpful in determining this. Given the subjective nature of pain and the complex nature of trigeminal neuralgia, we suspect that a clinical trial is required to determine efficacy. Intraoperative assessments of the therapeutic effect following sequential increases in temperature application to the nerve, similar in technique to that performed with radiofrequency rhizotomy, may be a reasonable paradigm to follow. In vivo studies of somatosensory evoked potential signal attenuation and histological analysis of cranial nerves in animal models of trigeminal neuralgia, we suspect that a clinical trial is required to determine efficacy. Intraoperative assessments of the therapeutic effect following sequential increases in temperature application to the nerve, similar in technique to that performed with radiofrequency rhizotomy, may be a reasonable paradigm to follow. In vivo studies of somatosensory evoked potential signal attenuation and histological analysis of cranial nerves in animal models of FUS may be of some value in parameter optimization prior to a clinical trial.

Stephen J. Monteith, MD
W. Jeff Elias, MD
University of Virginia Health System, Charlottesville, VA

References

TO THE EDITOR: With interest I read the article by Delgado Almandoz et al. about the diagnostic yield of CT angiography (CTA) and MR angiography (MRA) in angiographically negative subarachnoid hemorrhage (SAH) (Delgado Almandoz JE, Jagadeesan BD, Refai D, et al: Diagnostic yield of computed tomography angiography and magnetic resonance angiography in patients with catheter angiography–negative subarachnoid hemorrhage. J Neurosurg 117:309–315, August 2012). Computed tomography angiography demonstrated a cerebral aneurysm in 4 (9.3%) of 43 patients with aneurysmal SAH. Magnetic resonance angiography demonstrated only 1 of these aneurysms. No causative cerebral aneurysms were found in patients with perimesencephalic SAH or CSF xanthochromia. Three of these 4 aneurysms were, in retrospect, visible on angiography but were not recognized or interpreted as the cause of SAH.

In another article about the same patient group, diagnostic yield of repeat catheter angiography was assessed in patients with SAH and negative catheter angiography and CTA. The first repeat catheter angiography performed 7 days after presentation demonstrated a causative vascular abnormality in 3 (4.4%) of 68 patients, 2 with aneurysmal SAH and 1 with perimesencephalic SAH. The second repeat catheter angiogram obtained in 43 patients (59.7%) did not demonstrate any causative vascular abnormalities. In this scenario, a patient with an SAH without an aneurysm eventually undergoes 3 catheter angiography sessions, a CTA, and a MRA to confirm that there is no aneurysm.

This study again demonstrates that aneurysms can be missed fairly easily on catheter angiography as well as on CTA and MRA. This is not surprising since all 3 imaging modalities are no longer the best way to detect an aneurysm. In the late 1990s 3D rotational angiography became available for clinical practice. This technique has evolved into a quick and easy to perform procedure. In our hospital we have used 3D angiography as a primary imaging tool in patients with aneurysmal SAH for more than a decade (we reserve CTA for patients with perimesencephalic SAH only). A rotational run takes 6 seconds with manual injections of 12–18 ml of contrast material, which is much quicker and cheaper than a multiple projection 2D angiogram with 10 ml of contrast per projection. Reconstruction of the 3D images takes a few seconds.

In various studies we demonstrated the superior image quality and diagnostic yield of 3D angiography in comparison to 2D angiography. In 19 (83%) of 23 patients with aneurysmal SAH and negative 2D catheter angiography, 3D angiography demonstrated an aneurysm as the cause of SAH. Of 94 additional aneurysms detected with 3D angiography in 350 patients with a target aneurysm, 27 (29%) were missed on 2D angiography. Perhaps the best demonstration of the superior image quality of 3D angiography is in the detection of fenestrations in cerebral arteries in almost 40% of patients; most of these anomalies were, even in retrospect, not visible on 2D angiography.